"scarcely recognizable" appearance of the crab *Hyas* when covered with algæ, &c. Indeed, no one who has seen one of these crabs brought up with the dredge, or has found a well-covered *Stenorhynchus* on our own shores, can seriously doubt the usefulness of the habit in rendering the animal inconspicuous. In *Stenorhynchus* and *Inachus* the process of "dressing" with weeds and zoophytes has been described by Bateson (Journ. Mar. Biol. Association, vol. i. 1889, p. 213), and it is seen from his description that, as also in the cases of *Dorippe*, *Pagurus*, *Dromia vulgaris*, &c., the foreign substances or animals become attached to the body not by accident but by the act of the crabs themselves.

Now Mr. Walker, in regarding *all* these cases as instances of adaptation for concealment, has overlooked the fact that in two of our British species of hermit crab (*Pagurus bernhardus* and *P. prideauxii*) it is the habit of the animals to prefer, and often to fight for, shells which are rendered conspicuous by the attachment to them of species of Anemone, in the one case *Adamsia rondeletii* (*Sagartia parasitica*), in the other *Adamsia palliata*. Another British species (*Pagurus cuanensis*) is almost invariably found inhabiting a shell enveloped in the sponge *Suberites domuncula*, which is frequently of a conspicuous orange-red colour Only in the smallest species of *Pagurus* (*e.g.*, *P. lævis*) does the animal depend invariably upon an inconspicuous appearance for its safety.

The value to the crabs of a preference for shells to which Actinians are attached is found in the fact that these gaily-coloured animals are carefully shunned by fishes on account of their stinging powers; and although hermit crabs themselves are very palatable to fishes, their association with Actinians, while rendering them conspicuous as they move about, is at the same time an efficient protection from the persecution of their enemies.

This also explains the habits of the two Mauritian crabs, which, according to Möbius, carry about a sea-anemone in each claw.

The sponge with which *Pagurus cuanensis* is associated is (like all other sponges with which I have experimented) exceedingly obnoxious to fishes on account of its bad smell and taste. I have never succeeded in inducing a fish of any species to swallow a fragment of the sponge; but on the contrary the smell is in most cases quite sufficient to drive the fish away. The association with the sponge is therefore here also an efficient protection, for I know of no fish capable of extracting the crab from its retreat. It is seen from this that the case of *Dromia vulgaris* should probably be removed from the category of adaptations for concealment, and, like the cases of *P. bernhardus*, &c., be included in a special group of *warning* adaptations.

There yet remains the interesting case, adduced by Dr. R. von Lendenfeld, of *Dromia excavata* associated with a Compound Ascidian of the genus *Atopogaster* (Herdman). This, I believe, will be found to belong to the same category of warning adaptations, for after repeated experiments with Compound and other *Tunicata* at the Plymouth Laboratory I can state that these animals are essentially inedible to fishes. The inedibility is in large part due, as in the case of sponges, to the characteristic odour which *Tunicata*, and more especially Compound *Tunicata*, give out, and in no family (excepting perhaps the *Botryllidæ*) is this better marked than in the *Polyclinidæ*, the group to which *Atopogaster* belongs. Bearing in mind also the fact that Composite Ascidians frequently vie with sponges and Actinians in the possession of varied and conspicuous colours, it is rendered practically certain that the case of *Dromia excavata* is another instance of this same type of adventitious warning contrivances.

Thus the edible (the edibility is not yet proved for foreign species) *Crustacea* which attach foreign substances to their bodies may be divided into two groups:—

(*α*) Those which are rendered inconspicuous in relation to their natural surroundings by the habit; *e.g.*, *Stenorhynchus*, *Hyas*, *Dorippe*, *Pagurus lævis*, and young forms of *Pagurus bernhardus*, &c.

(*β*) Those which associate themselves with animals, easily recognizable by, and possessing qualities offensive to, their chief enemies; *e.g.*, *Dromia vulgaris* and *excavata*, *Pagurus bernhardus*, *prideauxii*, and *cuanensis*. WALTER GARSTANG.

Laboratory of the Marine Biological Association,
Plymouth, February 21.

P.S.—From facts which Mr. Weldon and Mr. Harmer have communicated to me, it would appear that *Dromia vulgaris* frequently attaches Compound Ascidians (*Leptoclinum maculosum*, *Botrylloides Gasconiæ*) to its back instead of sponges, a variation of habit which is very interesting in connection with the apparently fixed habit of the Australian species.—W. G.

A Key to the Royal Society Catalogue.

"A CATALOGUER" appears to have misunderstood me in two points. In the index that I propose, the heads would not be numbered. Again, in forming an estimate of the size of the work, I made the supposition that the 8 papers of an author could be grouped, not under 8, but under 3 heads.

JAMES C. MCCONNEL.

A Meteor.

LAST night (Monday, the 3rd), as I was crossing the Old Deer Park to Richmond, I witnessed the flight of an exceptionally fine meteor, which shone out with great brilliancy notwithstanding the presence of a bright moon, which was almost at the full.

It appeared to start from the constellation of Leo, and travelled across the sky to the westward, vanishing some 10° or 15° above the horizon.

The night was very quiet at the time, and I heard no report.

T. W. BAKER.

Kew Observatory, Richmond, Surrey, March 4.

THE DISCOVERY OF COAL NEAR DOVER.

THE question of the existence of coal under the newer rocks of Southern England, which has engaged the attention of some of our leading geologists since the year 1855, has found its final answer in the discovery announced last week in the daily press. The story of the discovery is a striking example of the progress of a scientific idea, passing through various phases, and growing more clearly defined through opposition and failure, until ultimately it has been proved to be true, and likely to lead to industrial changes of national importance.

The question was originally started 35 years ago by Mr. Godwin-Austen in a memorable paper brought before the Geological Society of London, in which it was argued, from the character and arrangement of the coal-fields and associated rocks of Somersetshire and South Wales on the west, and of the Belgian and North French coal-fields on the east, that similar coal-fields lie buried beneath the newer strata of the intervening regions. Mr. Godwin-Austen pointed out that the general direction of the exposed coal-fields was ruled by a series of great east and west folds, running parallel to the great line of disturbance—"the axis of Artois,"—from the south of Ireland, through South Wales and Northern Somerset on the west, eastwards through Belgium and Northern France, into the valley of the Rhine, near Düsseldorf. Throughout this area the exposed coal-fields lie in long east and west troughs. This series of folded Carboniferous and older rocks formed also an east and west ridge along the line of the axis of Artois, which gradually sank beneath the waves of the Triassic, Liassic, Oolitic, and Cretaceous seas. Against this the strata of the three first of these rocks gradually thin off, while the coal-measures and other rocks of the ridge have repeatedly been struck in France and Belgium, and are now being worked immediately underneath the Cretaceous strata over a wide area.

The axis of Artois also, where it is concealed by the newer rocks in the south of England, is marked from Somerset eastwards by the anticlinal of the chalk of North Wiltshire, and the line of the North Downs, the general law seeming to be "that when any great folding and dislocation of the earth's crust has taken place, each subsequent disturbance follows the very same lines, and that simply because they are lines of least resistance."

Mr. Godwin-Austen, by combining all these observations, finally concluded that there were coal-fields beneath the Oolitic and Cretaceous rocks of the south of England,

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and that they were sufficiently near the surface to allow of their being of great economic value. He further specified the line of the Thames Valley, and the region of the Weald, as possible places where they might be discovered.

These important conclusions were during the next 11 years generally received by geologists, with the exception of Sir Roderick Murchison. The next important step in the direction of their verification was that taken by the Coal Commission of 1866–67, by whom Mr. Godwin-Austen and Sir R. Murchison were examined at length, and the results of the inquiry embodied in the Report by Mr. Prestwich. In the Report, Mr. Godwin-Austen's views are accepted, and fortified by a vast number of details relating both to the coal-fields of Somersetshire and of France and Belgium. Mr. Prestwich also calls special attention to the physical identity of the coals of these two regions, and to the fact that the Carboniferous and older rocks in both are similarly disturbed. He concludes, further, that the coal-fields which now lie buried beneath the newer rocks are probably equal in value and in extent to those which are exposed in Somerset and South Wales on the west, and in Belgium and France on the east.

In 1872 the Coal Commission Report was published, and in the same year the Sub-Wealden Exploration Committee was organized[1] by Mr. Henry Willett to test the question of the existence of coal in the Wealden area by an experimental boring. The site chosen was Netherfield, near Battle, in Sussex, where the lowest rocks of the Wealden formation form the bottom of the valley. It was resolved to go down to the older Palæozoic strata, which were thought to occur at about 1000 feet from the surface, or to carry the bore-hole to 2000 feet if they were not struck before. The work was carried on under considerable difficulties for the next three years, until in 1875 it had to be abandoned at a depth of 1905 feet, because of the breakage of many hundred feet of lining-pipes, coupled with the loss of the boring-tool at the bottom. The section of the strata passed through is as follows:—

Netherfield Section.

	Feet.
Purbeck strata	200
Portland strata	57
Kimmeridge Clay[2] ...	1073
Corallian rocks[2]	515
Oxford Clay	60
	1905

This section, although it yielded no information as to the Palæozoic rocks, showed that in this particular district they are more than 1900 feet beneath the surface, and revealed the great thickness of the Kimmeridge Clay and Corallian rocks, sufficiently distant from the ridge of coal-measures and older rocks, against which the Oolitic strata thin away to the north, to allow of an accumulation of Oolitic sediments to a thickness of more than 1700 feet. In this respect, therefore, it afforded unmistakable evidence that the search for the ridge in question might be carried on with much greater chance of success further to the north, in the direction of the North Downs. The great and increasing thickness of the successive newer rocks of the Wealden formation, which form the surface of the ground between Netherfield and the North Downs, rendered it undesirable to repeat the experiment within the Wealden area proper. Close to Battle, the Secondary strata were of great thickness, and where the whole series of Wealden rocks were present, they were more than 1000 feet thick.

For the next eleven years the problem remained where it was left by the results of the Netherfield boring; while in the district of London, evidence was being collected in various sinkings for water, which proved the existence of the Palæozoic ridge of rocks, Silurian and old red sandstones, older than the Carboniferous, at about 1000 feet from the surface. Here, too, the Oolitic strata were not more than 87 feet in thickness, at their thickest point in the well at Richmond. The older rocks, moreover, were inclined at a very high angle, as in the case of the similar rocks underlying the coal-fields of Somerset, and of Northern France and Belgium, and this implied the existence of troughs of coal-measures in the synclinal folds, in neighbouring areas.

I come now to the last experiment, which has been so fortunately crowned with success. In 1886, I reported to Sir Edward Watkin that it was desirable, both on scientific and commercial grounds, for a boring to be put down in South-East Kent, in the neighbourhood of Dover, and that the Channel Tunnel works under the Shakespear Cliff would be the best site for the experiment. It was almost within sight of Calais, where the coal-measures had been proved at a depth of 1092 feet. It was also not many miles away from the spot where a large mass of bituminous material—which, according to Mr. Godwin-Austen, was the result of the distillation of coal from the measures beneath—had been discovered in the chalk. Sir Edward Watkin acted with his usual energy on my report, and the work was begun in 1886, and carried on, under my advice, down to the present time. The boring operations have been under the direction of Mr. F. Brady, the chief engineer of the South-Eastern Railway, to whose ability we owe the completion of the work to its present point, under circumstances of great difficulty. The strata passed through may be generalized as follows:—

Section at Shakespear Cliff, Dover.

	Feet.
Lower Grey Chalk, and Chalk-Marl	500.
Glauconitic Marl	
Gault	
Neocomian	
Portlandian	660.
Kimmeridgean	
Corallian	
Oxfordian	
Callovian	
Bathonian	
Coal-measures, sandstones, and shales and clays, with one seam of good blazing coal, struck at 1180 feet from the top of the bore-hole	20

The coal-measures were struck at a depth of 1160 feet, or 68 feet below the point where the coal-measures were met with in the boring at Calais. It may also be noted as a remarkable confirmation of Mr. Godwin-Austen's views as to the abrupt thinning off of the Wealden strata, that, although along the line of the North Downs the Weald clay strikes towards the French coast, and is seen at low water between Hythe and Folkestone, it and the underlying Wealden strata are not represented in the section at the Shakespear Cliff.

It is too soon as yet to measure the full value of this discovery near Dover, while our work is as yet unfinished. We may, however, remark that the coal-fields of the Continent, which have been proved beneath the newer rocks in Northern France and Belgium, some 60 miles to the west of their eastern outcrops, have now been traced across the Channel, that they are at a workable depth, and that we have now a well-defined base for further researches in Southern England.

W. BOYD DAWKINS.

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[1] The Committee consisted of Profs. Ramsay and Phillips, Sir John Lubbock, Sir Philip Egerton, and Messrs. Thomas Hawksley, Warington Smyth, Prestwich, Bristow, Etheridge, Boyd Dawkins, and Topley.

[2] The precise boundary between these two groups is uncertain. If the Kimmeridge Clay series be taken down to the Coralline Oolite, its thickness will be 1512 feet.

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